IMPROVING STUDENT ACHIEVEMENT

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A cognitive processing capacity model of teaching and studying improved immediate posttest and delayed posttest performances of low-ability students, while it reduced performance differences between the low- and high-ability students. A skeletal study outline and a restudy and retest provision also made positive contributions to performance.

Many college closings are predicted for the 1980s because of a drop in the eligible college-age population. Even today, many institutions of higher education are feeling the economic effects of a reduced student population. These effects are aggravated by the attrition rate, especially during the freshman year. Therefore, one problem that faces all institutions of higher education is how to retain their students. Beyond this purely economic reason, however, all institutions have a moral obligation to make it possible for their students to obtain the best education.

At the institution of higher education where the experiments described in this paper took place, two related problems demanded attention: first, students having a low cognitive processing capacity (CPC)—memory as measured by a test to be described below—represented one-half of the withdrawing freshmen. In numbers, they actually represented about 16% of the entering freshman population. Second, only a small proportion of conditionally accepted students were passing with grades of C or higher. When these conditionally accepted students were given a CPC test, they were also found to have low CPC scores. The challenge, then, was to develop a course that would make it possible for these low-CPC students to succeed.

In developing such a course, the Keller Method or Personalized System of Instruction (PSI) (Keller, 1968; McKeachie, 1972) was considered. Studies that

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considered the SAT as a variable implied that the PSI effectively added an equal amount to test scores regardless of student ability levels (Morris & Kimbrell, 1971). While the PSI had many desirable features, something more than adding an equal increment to the low-SAT students' performances was felt to be necessary. More importantly, PSI did not consider individual differences in CPC. Consequently, the decision was to look elsewhere for a method to use.

A series of studies by Furukawa (e.g., Furukawa, 1970, 1977), suggested a CPC model of teaching and studying. The CPC model is based on three factors: (1) CPC, (2) pyramidal structure of knowledge, and (3) chunking. The *CPC* of a student is determined by a simple test consisting of two lists of 20 adjective-noun pairs (e.g., fresh strawberries) (Furukawa, 1977, 1978). After a 1-minute study period, in which one of the lists is shown in its entirety by an overhead projector, students are allowed 2 minutes to write the words down in any order. This process is repeated with the second list. Each correctly recalled word is scored one-half point for a possible 20 points for each list. The average of the sum of the scores on both lists is the CPC of a student. This CPC tells the student how many items of information he or she can profitably process during a brief exposure to them.

The CPC test appears to be a measure of long-term rather than short-term memory (Furukawa, 1977). For example, the correlation between CPC scores and performance scores on a prose learning task increased over time, from immediate to delayed posttests. Like a short-term memory test, however, CPC appears to impose a limitation upon a learner's ability to process information that is shown for a brief interval. The mean and standard deviation of this limitation appear to be 7 and 2 (cf. Miller's magical number) (Miller, 1956).

CPC seems to function as a limiting variable. Performance scores of the learner tend to decrease as the quantity of information to be processed increases (Furukawa, 1970). This "aptitude-by-treatment" interaction was found to be significant during the initial stages of learning (Furukawa, 1970). The relationship between CPC and posttest performances, however, appeared to be curvilinear, with depressed performances resulting when the learning tasks were "too simple" or "too difficult" in terms of information load for a subject with a particular CPC score. In other words, lower test scores resulted when the learner was given too few or too many units of information to process in relationship to his or her CPC. In the former case, the perceived simplicity of the task may delude the learner into thinking that additional rehearsals are not necessary; in the latter case, the learner's rehearsal may be interfered with because of an information overload. Based on these and other data, Furukawa's CPC test appeared to be a measure of levels of processing (Craik & Lockhart, 1972) instead of short-term memory.

CPC may also be a measure of inherited factors and acquired knowledge factors (Furukawa, 1978). We will focus on acquired knowledge, which may be

roughly dichotomized under the rubrics of subject matter and study strategies. Learning would, of course, involve an interaction of these two variables. Therefore, any model of teaching and studying that attempts to improve learning should consider both variables in order to be viable.

The second major component of the model, the *pyramid of knowledge,* recognizes that practically all knowledge has a vertical and a horizontal structure. At the college level, the pyramid of knowledge can be tentatively equated with an outline of a lecture or of a book. Such an outline would reflect a vertical and horizontal structure of headings, subheadings, and key words categorized under a system of Roman numerals, capital letters, Arabic numerals, and so on (see Table 1 for an example).

In length, this outline differs from a lecture-note outline. Whereas the usual outline consists of complete statements, the outline that is recommended consists of "headings" and key words that are normally the subjects (nouns and adjective-noun pairs) of paragraphs and sentences. Subjects are chosen for inclusion on this outline because they have the greatest redintegrative power or cue value in recalling information in a sentence (Horowitz and Prytulak, 1969). Since the primary purpose of the outline is to facilitate chunking of the discrete units of information, the outline is called the chunking study outline (CSO).

Chunking is the third component of the CPC model of teaching and studying. It is a process whereby relatively discrete units of information are integrated into a single, meaningful whole. The terms "relatively discrete" and "a single, meaningful whole" require explanation. First, let's look at a simple example to establish a basis for a more sophisticated one. When a child first encounters the letters *c, a, p, i, t, a, l,* these letters are initially "relatively discrete units of information," individual letters that do not convey meaning. As the child continues to examine the group of letters, a letter cluster or two (e.g., *cap, it*) may be discovered. Using these letter clusters as a foundation, the child soon realizes that the letters form the word *capital;* thus "a single, meaningful whole" emerges.

At a more sophisticated level, chunking progresses in a two-tiered sequence. Assuming that the CSO of a textbook chapter is involved, chunking should proceed as follows. In the initial stage, the student determines how much of the text to read. This determination is simply a matter of counting lines on the CSO—each line being a unit initially—until they match the student's CPC. To maintain the meaningfulness of a section or paragraph of the text, it may be necessary to decrease or increase the quantity counted. Once the quantity to be studied is determined, the student refers to the textbook and begins reading. Next, when the reading is completed, the student uses the key words in the CSO to try to recall all related information. Should recall fail, the student returns to the book and rereads only the part referring to the forgotten material.

When the review is successfully accomplished, these relatively discrete units

TABLE 1. Sample of Short and Long Chunking Study Outlines.

Short Outline

I. Three levels of memory (p. 178)
   A. Levels
      1. Sensory store
      2. Short-term memory
      3. Long-term memory
   B. Sensory store
   C. Short-term memory
      1. Seven items
      2. Chunking
      3. Rehearsal
      4. Retrograde amnesia
      5. Coding
   D. Long-term memory
      1. Highly organized
      2. Retrieval
         a. Accessible
         b. Available
      3. Cueing
         a. Mnemonic device
         b. Categories

Long Outline

I. The three levels of memory (p. 178)
   A. Sensory store
      1. First receives information coming in from our sense receptors
   B. Short-term memory
      1. Attention span
      2. Limited capacity for storage
         a. Can only hold 7 items of information at any given time
      3. Chunking
         a. Grouping information together so more can be retained
      4. Rehearsal
         a. Repetition necessary for material to be transferred into long-term memory
      5. Retrograde amnesia
         a. Inability to recall events that took place immediately before a critical event
      6. Coding
         a. Compressing information into abbreviated form
   C. Long-term memory
      1. Highly organized and relatively permanent
      2. The retrieval process
         a. Means by which one draws upon information in long-term memory
         b. Available memory

TABLE 1 ***(Continued).***

(1) Information stored in long-term memory but not necessarily retrievable
c. Accessible memory
(1) Information that can be tapped
3. Cueing
a. Checking each of a number of categories in turn until one finds the desired information
b. Categories
(1) Grouping based on similarities among items.

are chunked by using their heading as a nexus to subsume the information. In other words, when the student later looks at the nexus word, all subordinate information should be recalled. If not, further practice is called for. The student progresses by repeating the process: count, read, review, and reread, as necessary. Also, after each set of units of information is successfully reviewed, the one just prior to it should be reviewed again: learn a new set, review a previous one.

When the entire chapter has been studied and reviewed, the second and final stage of review takes place. The initial chunking was essentially a bottom-up process, but this time the converse occurs. A top-down process takes place by using the chapter title as the nexus and annexing all Roman numeral headings to it. Finally, all capital letter headings, if not already integrated with the Roman numeral headings, should be chunked. The chapter headings, in turn, could be subsumed under the nexus of part headings and, ultimately linked to the title of a book or a course. As Mandler (1969) stated, the chunking progression is almost limitless.

To summarize, the model of teaching and studying consists of three factors: CPC, pyramid of knowledge, and chunking. The CPC is used to gauge the quantity of information to be learned. The pyramid of knowledge, or CSO, is used to select quantities of information from and to act as a framework for chunking. Because of the primary role played by CPC, the model is called the *CPC model of teaching and studying*. The experimenters felt that the model's flexibility in adjusting to individual differences in CPC should serve as a basis for developing a course that would make it possible for low-CPC students to succeed.

EXPERIMENT 1

The primary goal of experiment 1 was to determine whether the CPC model of teaching and studying would improve the 38 percent passing rate (grade of C or higher) of the conditionally accepted students in general psychology.

Method

Design. One of the experimental designs selected was a variation of the recurrent institutional cycle design (Campbell and Stanley, 1963). The variation consisted of a pretest for both groups (A and B) instead of one. The rationale for using this design was to eliminate two undesirable features found in PSI studies examined by Ryan (1974). The first of these was the problem of uncontrolled prior differences between classes, which was eliminated by giving pretests to both groups to determine equivalency. The other problem was the lack of agreement in calculating final grades (McKeachie, 1972). This was controlled for by using cross-sectional (between classes A and B) and longitudinal (pre- and posttest for both classes A and B, separately) comparisons, both based on near-identical tests. A third undesirable variable, extraneous factors introduced by being taught by different instructors, was also eliminated.

The other design selected involved a comparison of students in a baseline year with those in the experimental groups (classes A and B). The last comparison was between experimental groups of conditionally accepted students and regularly admitted students enrolled in general psychology courses during the same period.

Subjects. The experimental group consisted of 52 subjects, all with SATV scores of 350 or less. They were taught in two separate classes: Class A with 25 students during a five-week summer session, and Class B with 27 students during the normal fall semester. There were 58 students of like ability in the earlier baseline year.

Materials and Procedure. Four tests were administered prior to the beginning of the general psychology classes. These tests included a CPC test (Furukawa, 1977), two pretests (one on the CPC model of studying and the other on general psychology), and a vocabulary test (consisting of words taken from the early chapters of the general psychology textbook). As a student completed studying a chapter, a criterion test was administered to determine mastery. There were five end-of-unit tests, one on the CPC model of studying and four on the psychology textbook. While the "posttest" designation used in this paper refers to the average of the textbook tests only, a minimum of 60 percent of the five 40-item multiple-choice tests had to be correct for a student to obtain a grade of C.

Study skills. An evaluation of the pretest on study skills showed a lack of knowledge in this area. Therefore, the students spent the first week in studying the CPC model of studying from a programmed instruction booklet (Furukawa, 1978). The booklet was designed for medium- and low-CPC students, with every few paragraphs of text material followed by five to seven completion questions and answers. Each chapter ended with a CSO, which the students used to prepare for tests.

General psychology. The students studied a general psychology text (Morris, 1976) in a five-step sequence. In the first step, at the beginning of each chapter, a listing of the major chapter headings was placed on the chalkboard and was briefly discussed. This listing served to bind the headings into a unit (Wertheimer, 1938) and to act as an advance organizer (Ausubel, 1968). In step two, an overview of each chapter was presented in an audiovisual format with a Singer Caramate. The visual portion was a brief outline of the audio overview. In step three, students followed a study sequence in reading certain paragraphs from the book and then answering an average of five questions in an accompanying workbook (Moss, 1976). This requirement was designed to prevent an information overload, especially for the low-CPC students. In step four, students used the CSO for test preparation. Finally, the students took a written criterion test for a chapter and were also verbally quizzed to see if they had mastered the key concepts and principles.

Instruction. Four instructors (a professor and three teaching assistants) conducted large and small group (about six students to an instructor) activities and provided individual tutoring and counseling as needed. Large-group activities included taking end-of-unit tests and discussing general interest items, such as class test scores, questions, and study recommendations. Small-group activities included: (1) learning unknown words from the preliminary vocabulary test list; (2) participating in group discussions of text or study skill material; (3) studying independently by viewing and listening to Singer Caramates programmed with an overview of a chapter and by reading a chapter guided by a study sequence, a workbook, and a CSO; (4) taking advantage of individual tutoring and counseling sessions. Chapter criterion tests were also taken in small groups, and immediate feedback was given. The major portion of class time was spent in small-group activities. When the course ended, the students had a chance to evaluate it.

Results

The mean CPC score of the students was about 5.09, with a standard deviation of 1.40. The mean of the university population was about 7, with a standard deviation of about 2. A comparison of *pretest* scores (11.20 and 12.60 for classes A and B, respectively) showed no significant difference. The *posttest* mean score of Class A (26.29) was significantly higher than the *pretest* mean score of Class B (12.60), $t\ (48) = 13.55, p < .001$.

Classes A and B both had a significantly larger percentage of students passing with a grade of C or higher when compared to the students in the baseline year, $X^2\ (1) = 35.69, p < .001$ and $X^2\ (1) = 22.45, p < .001$, in that order. Although class A students surpassed the success rate of the regularly admitted students at a significant level, $X^2\ (1)\ 6.70, p < .01$, the class B students did not. Nevertheless

11 percent more of the class B students passed in comparison to the regularly admitted students.

Discussion

The results appeared to support the CPC model of teaching and studying because (1) a latitudinal comparison found the students in class A to be significantly better on test performance at the end of their course than were the students in class B at the beginning; (2) the longitudinal comparison found class B students had improved significantly from pretest to posttest; (3) both classes had significantly more students passing with a grade of C or higher than the students in the baseline year; (4) the students in the experimental classes were equal to or superior to the regularly admitted students who were enrolled at the same time; and (5) the average passing rate of students in classes A and B was 90 percent compared to the baseline-year students' passing rate of 38 percent. In short, the students had more than doubled their pretest scores and their success rate.

The withdrawal and noncompletion rate was 4 percent. This compares very favorably with the usual 6 to 15 percent rates found for normal and PSI courses (Ryan, 1974). It is speculated that the low-CPC students benefited particularly during the summer because they could concentrate their efforts on one course.

Three possible limitations of the study should be mentioned. First, there may have been a Hawthorne effect; if so, the effect may be used to the benefit of the students. Second, there may have been a regression-to-the-mean effect for the low ability students; if so, the same phenomenon should have affected the baseline group, but it apparently did not. Third, pretest sensitization may be charged. However, there were several pretests and a criterion test for every chapter before an end-of-unit test was taken. If there is pretest sensitization, it is a normal feature of the CPC model of teaching and studying as well as the PSI method. In short, these limitations may be more academic than real.

The student evaluations were unanimously in favor of continuing the course for other conditionally accepted students, and it was suggested that the course be made available to other interested students. When asked what they liked most about the course, students listed course organization (small group activities and working at their own pace), course materials (study skills booklet, general psychology textbook, study sequence, CSO, and films), and attitude of the instructors. The least liked features were the Caramate instruction and the large quantity of information which had to be mastered. Of the teaching aids evaluated separately, Caramate instruction rated lowest, and the CSO received the highest mark. In all probability, the student responses in favor of the CSO indicated how valuable it was to them.

Three educational implications are suggested: (1) the CPC test may be administered to students to measure their learning capacity; (2) students may profit from learning and using the CPC model of studying; (3) instructors may consider

using the CPC model of teaching to structure the classroom environment to facilitate learning.

EXPERIMENT 2

The first experiment asked and answered a broad question: Will the use of the CPC model of teaching and studying result in an improvement of the success rate of conditionally accepted students? Once a positive answer was obtained, additional questions had to be asked and answered. This second experiment searched for answer to the following questions:

1. Will differences in the length of the CSO affect test performances?
2. Will the retention rates differ significantly from the immediate to delayed posttests?
3. Will the retention rates differ significantly, depending upon the type of knowledge measured (i.e., discrimination learning, concept learning, rule learning, or problem solving)?
4. Will there be a difference in test performances between high- and low-CPC students?

The first question on the length of the CSO was based on its assumed value to the CPC model of teaching and studying because it facilitates counting units of information, organizing the materials, and chunking the information. The CSO should contain essential information only. Nevertheless, many students were observed to be disregarding this caveat and adding, for example, complete definitions and descriptions to the key words provided. The value of such additions needed to be tested. Parenthetically, it should be noted that the question of CSO versus no CSO appeared to have been answered in favor of the CSO by another study (Furukawa, 1977). In that study, a chunking programmed instruction unit with the CSO was found to be superior to an identical unit without the CSO.

The second question, on retention rate differences, can be traced to earlier studies by other investigators. Sterrett and Davis (1954) surveyed retention rates of information learned at the elementary, secondary, and college levels and concluded that "factual material is readily forgotten whereas concepts and principles are retained with little loss over long periods" (p. 457).

There were also two studies dealing specifically with general psychology: one by Jones (1923) and one by McKeachie and Solomon (1957). Jones found that most of the facts learned in a college psychology course were forgotten quickly, with only 35 percent being retained after 8 weeks. After deducting pretest knowledge (54 percent) from a test given at the end of the course (73.5 percent) and one given about 8 months later (70.7 percent), McKeachie and Solomon reported that there was an 85.6 percent retention rate over the same span.

Based on the retention-rate studies, the third and corollary question on reten-

tion rate differences was raised. According to Gagné's (1965) classes of behavior, there is a hierarchy of behaviors, with problem solving at the apex and signal learning (classical conditioning) at the base. Judging from the studies cited earlier, problem solving, rules (principles), and concepts should be remembered most and discrimination learning remembered least. Nevertheless, the objective of general psychology courses is to teach concepts and principles and not problem solving, which is usually reserved for advanced courses in psychology. The answer to the third question as expected to shed some light on the achievement of course objectives.

The fourth question, on differences in performances between high- and low-CPC students, was based on earlier findings of a consistent disparity between the performances of high- and low-CPC students. Examples of this disparity have been found with different learning modes (Furukawa, 1977) and with different information loads (Furukawa, 1970). The viability of the CPC model of teaching and studying could be further established if it were instrumental in eliminating or reducing performance differences between high- and low-CPC students.

Method

Subjects. The data presented here were gathered in three separate general psychology classes that included regularly admitted students. Two classes participated in the study on CSO length and one in the study on retention rates. In comparison to the retention-rate study class, the CSO-length classes had a somewhat restricted range of CPC scores.

Materials and Procedure. To answer question one on the effects of CSO differences on test scores, a counter-balanced experimental design was used: One class of students received short CSOs for three chapters and long CSOs for the next three chapters (See Table 1 for an abbreviated version of both types of CSO), and a second class of students had the short and long CSOs in reverse order. A 40-item, multiple-choice immediate posttest was administered after every three chapters.

The retention rate study used two repeated measures designs. The first was to answer question two on possible retention rate differences: the repeated measures consisted of an immediate posttest of 10 multiple-choice questions on materials covered in the first chapter of the textbook and a delayed posttest of 12 questions administered about three months later. To answer the third question on possible differences in retention rates based upon the type of knowledge measured, the aforementioned delayed posttest was divided into four parts of three questions each on discrimination learning, concepts, rules or principles, and problem solving. All students rereceived a short CSO for the chapter. Finally, to aid in answering the fourth question on possible differences in test performances between high- and low-CPC students, tests of CPC and a pretest on general psychology were administered to all students.

Results

The results are presented in the order in which the questions were raised: CSO length, retention rates, and CPC. The results showed a statistically significant difference favoring the short CSO, t (51) = 2.73, $p < .01$. The mean scores were separated by 1.50 points. Translated into letter grades, as many as 38 percent of the students who used the longer CSO for a particular test could have received a higher letter grade by using the shorter CSO.

Retention rates differed slightly between immediate and delayed posttests. On the immediate posttest, which was given after the completion of the study of three chapters, students remembered 72 percent of the materials on the chapter tested. On the delayed posttest, covering the same chapter after a time lapse of approximately 3 months, 66 percent of the materials were recalled. Adjusted for prior knowledge (pretest scores) of 32 percent, these percentages become 40 and 34 percent, respectively, for an overall retention rate of 85% over the 3 months. When the delayed posttest was adjusted to omit problem-solving questions—the justification for this was presented above and is substantiated in a paragraph to follow—the delayed retention percentage became 70 percent, or 38 percent with adjustment for prior knowledge. In other words, with the adjustment to omit problem-solving questions, the retention rate over the three month period was 95 percent.

An analysis of the delayed posttest in terms of types of knowledge tested, namely, discrimination learning, concept learning, rule learning, and problem solving, revealed mean scores of 1.93, 2.19, 2.17, and 1.65, respectively. An analysis of variance for repeated measures was significant, F (3, 369) = 13.36, $p < .001$. A further analysis showed that rule learning was significantly superior to discrimination learning, F (1, 123) = 8.06, $p < .01$. Therefore, differences between concept versus discrimination learning and rule and concept versus problem solving were also significantly different, at least at the .01 level.

The performances of the high-CPC students were found to be superior to those of the low-CPC students on the delayed posttest only, t (86) = 1.73, $p < .05$, with mean performance scores of 8.38 and 7.76, respectively. The correlation between CPC and immediate test scores was .13, and for the delayed test, the correlation was .10. Neither of these correlations was significant.

Discussion

The findings appear to support these conclusions:

1. The CSO used in the chunking model of teaching and studying should be a short one limited to headings of chapters, sections, and subsections and key words. The key words can be nouns or adjective-noun pairs that are subjects of paragraphs and sentences.

2. The retention rate following learning with the CPC model of teaching and studying may be near perfect at 95 percent or at least at the 85 percent level, with over a 100 percent gain over pretest scores.
3. Test performances were affected by the type of knowledge tested, with students doing best on concepts and rules.
4. Cognitive processing capacity differences may continue to have some effect on long-term retention, but the relationship between CPC and performance appears to be minimal when using the CPC model of teaching and studying.

The effect of CSO length differences probably can be attributed to two related factors. First, the more information given, the greater the probability that the information load will overtax the CPC of the learner. Second, the more information available, the greater the difficulty of chunking the information, to include the selection of nexus words.

One other factor may have operated to influence the effectiveness of the learning process. When all of the information was available for reading (e.g., a word and its definition), less effort may have been expended in reviewing. The learner may have read everything and understood the information. Unfortunately, understanding and remembering are two different processes.

The retention rates may be considered to be superior because of the percentage of information retained, of the gain over pretest scores, and of the somewhat limited ability of the students involved. This third point can be illustrated by the low CPC scores of many of the students and by the percentage of the information originally known on the pretest. In the McKeachie and Solomon study (1957), 54 percent of the information was already known compared to 32 percent in the present study. In short, the students may have gained nearly twice as much as those in the McKeachie and Solomon study and yet managed to retain the same percentage or more.

Testing for knowledge in the four categories of discrimination learning, concept learning, rule learning, and problem solving provided us with new insights on the attainment of course objectives. In introductory courses, the main objective is the mastery of concepts and principles. These are then used in future learning of more complex psychological principles and in correct application of these principles in appropriate real-life situations. The results point to the efficacy of the CPC model of teaching and studying in the learning of concepts and principles.

A substantial relationship between CPC and posttest performance has been found in earlier studies (e.g., Furukawa, 1970, 1977). In those studies, the relationship appeared to increase from immediate to delayed posttests, unless chunking had taken place. In the present study, chunking probably occurred, as the relationship between CPC and test performance decreased slightly from immediate to delayed posttest, and both correlation coefficients were not significant.

Nevertheless, CPC differences seem to have had some influence on delayed posttest performance, with the high-CPC students being superior to the low-CPC students. This seemingly contradictory effect may be partially explained by the fact that the latter test was an extreme groups analysis which omitted the medium-CPC subjects. The medium group may represent a good deal of variability, with performances being affected by other factors besides CPC. In the final analysis, the possibility exists that low-CPC students may need to carry a reduced credit-hour load to give them more time to increase original learning and to overlearn the information for long-term retention.

EXPERIMENT 3

This investigation attempted to assess the contributions made by specific testing procedures to the CPC model of teaching and studying. Specifically, the questions asked in the present study were:

1. Do the chapter criterion tests lead to measurable differences in performance on the end-of-unit tests given after every three chapters?
2. Do retests lead to higher test grades and to increased long-term retention?
3. Do high-CPC students surpass the test performances of low-CPC students?

Method

Subjects. One hundred and eighty-one students in a general psychology class participated in the study. Due to normal withdrawals from class, absences, and other specific reasons to be considered later, not all of the students were included in all of the analyses discussed. The mean CPC score of the class was 5.79, with a standard deviation of 2.07. Based on these statistics, the high-CPC designation was applied to students with a CPC of $\geq$ 8.00 and the low designation to those with a score of $\leq$ 4.00. The medium CPC scores were 5, 6, and 7. These divisions resulted in 29 students being categorized as high-, 50 as low-, and 102 as medium-CPC students.

Materials and Procedure. At the beginning of the course, the students took a CPC test and then mastered principles of the CPC model of study from a programmed booklet (Furukawa, 1978). Next, they learned a chapter of the general psychology text (Morris, 1976) by applying the CPC model. To facilitate use of the CPC model of studying, a CSO was provided for each chapter. Also, a student assistant instructor (a senior or graduate student) was available to each group of 15 to 20 students. Third, the students were given the option of taking a criterion test consisting of 20 multiple-choice questions after studying the contents of a chapter.

As an inducement to take the criterion tests, which were to answer the first

question on measurable differences in performance on the end-of-unit tests, the students were told that a grade of A or B (85 or 75 percent of the test items correct, respectively) would lead to the award of one-third of a point. If at least two-thirds of a point was earned over the three criterion tests, then an extra point would be added onto the next end-of-unit test score. The students were also told that the extra point would probably mean a higher letter grade for 20 or 30 percent of the class and was, therefore, a worthwhile effort. The criterion tests would also give the students an approximation of their end-of-unit test scores; that is, As or Bs on the criterion tests would probably mean that they would get an A or B on the end-of-unit tests. An unmeasured aspect, of course, was the higher grades achieved on the end-of-unit tests as a result of the effort expended in passing the criterion tests. If the students failed to get As or Bs on the criterion tests, analyses of errors were made by the assistant instructors for the students, and further studies of weak areas were encouraged.

For all of the end-of-unit tests except the last one, the students were given the option of retaking the tests. If this option was exercised, the grade for the unit was based on the second test, be it higher or lower than the original test score. The students always had two days to prepare for retests. For the purpose of allowing retests, several alternate forms of the tests were used. These retests made it possible to answer the second question on whether a significant number of grades increased on the retest.

A 12-item multiple-choice test covering the materials on the first unit was administered after approximately 3 months had elapsed since the end-of-unit test. The experimental design was a 2×2, with immediate and delayed posttest scores being compared for students who took the retest and those who did not. A second planned analysis of the delayed post was to determine long-term retention differences based on test item similarity. Therefore, the test items were evenly divided into questions which were on the initial test, questions which were only on the pretest, and questions which were on neither one of the previous two tests.

The last question on performance differences between high- and low-CPC students was analyzed by comparing the number completing criterion tests and those who did not and the number obtaining various grades (A and B, C, D, and F).

Results

The data are presented in the same order in which the questions were asked earlier: questions on criterion tests, retests, and CPC. The analyses of criterion tests and retests were limited to the first of the general psychology tests because the immediate posttest (IPT) versus delayed posttest (DPT) comparison was based on the first test.

The addition of the single point earned on criterion tests to the first end-of-unit

TABLE 2. Means and Standard Deviations on Immediate and Delayed Posttests for Retest and No-Retest Groups.

Groups	Immediate posttest		Delayed posttest	
Retest	Mean:	4.87	Mean:	4.23
	SD:	1.16	SD:	1.18
No-retest	Mean:	5.88	Mean:	4.16
	SD:	.84	SD:	1.12

test score increased the letter grades of 13 percent of the students. Furthermore, 19 percent of those students who did not complete the required number of criterion tests could have raised their letter grades by taking the tests and earning an extra point.

The retest for the first end-of-unit test was taken by 46 students. A significant number (31 or 67 percent) of them achieved a higher letter grade, while no one experienced a drop in letter grade, X^2 (1) = 4.88, $p < .05$. The means and standard deviations for the original and retest scores were 24.15, 5.51, and 28.22, 5.44, respectively.

The retention rate over a period of approximately 3 months was evaluated by a 2×2 factorial design. The original plan was to determine whether there would be any differences among the three types of test questions: those which were on the original test, those which were on the retest but not on the original test, and those questions which were on neither one of the other two tests. However, no significant differences were found between the test and retest groups on these questions. Therefore, the analysis of variance was conducted on the posttests (IPT and DPT) collapsed across all types of test questions for the no-retest and retest groups (see Table 2).

The analysis showed no significant difference between no-retest and retest groups, but there was a significant difference between IPT and DPT, in favor of the former, F (1, 32) = 32.45, $p < .001$. There was a significant interaction, F (1, 32) = 6.92, $p < .025$. The locus of the interaction was a significant difference, F (1, 32) = 8.45, $p < .01$, on the IPT between the no-retest and retest groups favoring the former, but there was no significant difference on the DPT. A separate analysis showed a pretest to DPT gain of 88%.

As for the third question on differences in performances between high- and low-CPC students, it should first be noted that a significantly larger percentage (90 percent) of high-CPC students, as compared to 71 percent of the low-CPC students, completed two or all three criterion tests, X^2 (1) = 7.42, $p < .01$. The results revealed that more than twice as many As and Bs were obtained by the high-CPC students with about a fourth less Ds and Fs on the first test. Conse-

TABLE 3. Final Grade Distributions.

Cognitive processing capacity	A and B grades	C grade	D and F grades
High	83%	10%	7%
Medium	59%	26%	15%
Low	44%	42%	14%

quently, a significantly larger proportion of the low- instead of the high-CPC students retook the test (31 percent of 49 vs. 17 percent of 29), X^2 (1) = 4.08, $p < .05$. Of the five high-CPC students who retook the test, 60 percent increased their letter grades, and of the 15 low-CPC students who retook the test, 73 percent increased their letter grades. Because of the small number of high-CPC students retaking the test, no statistical comparisons were made. However, the difference between the means of the two groups decreased somewhat from 7 to 5.53 from test to retest. The correlations between CPC scores and test scores were .37 and .40 on the test and retest, respectively, both coefficients being significant at the .001 level, with the degrees of freedom being 76.

The foregoing findings led to a post hoc analysis of final grades received by the class. The final grade, assigned by averaging letter grades across five tests, showed the percentage distribution given in Table 3. Note that 93 percent of the high CPC students and 86 percent of the low CPC students successfully passed the course with grades of C or higher. This difference in success rates was not significant.

Discussion

Chapter criterion tests appear to have a direct effect on letter grades under the conditions specified here, where a point can be added to end-of-unit test scores. That is, 13 percent of the students increased their letter grades by earning the extra point. What is not apparent from these percentages is the degree of achievement attained because of the effort made in reviewing for and after the criterion tests. If we consider the other evidence of the value of the retests found on the IPT and DPT, studying for the criterion tests seems to be strongly recommended. For example, on the original test there is a significant difference between the two groups (those who took only the original test and those who retook the first test), favoring the group that did not retake the test. However, there seems to be no significant difference between the two groups on the DPT after the intervention of the study for the retest.

The retests also appear to be a beneficial part of the CPC model of teaching

and studying. Of the 46 students who retook the test, 31 or 67 percent improved their letter grades. Since a larger proportion of low- instead of high-CPC students retook the test, the option of retaking tests is certainly to the advantage of the former. This advantage becomes doubly important when the retention rates are examined. The results indicate that retaking the tests increases long-term retention of the information so that the significant difference that existed on the original test is eliminated. In fact, the mean of the students who retook the test is slightly higher on the DPT. A pretest-posttest comparison shows an 88 percent increase in knowledge across all students.

Clearly, the high-CPC students appear to have an advantage over the low-CPC students. More than twice as many As and Bs were obtained on the first test by the high-CPC students with about one-fourth less Ds and Fs. Stated in terms of mean scores, the high-CPC students scored about 5.5 points better on the 40-item test. Table 3 shows, however, that it is possible for an equal number of high- and low-CPC students to pass the course. We should note, nevertheless, that the chances of failing are proportionately greater for the low-CPC students, students with CPC scores ≤ 4.00.

As for the criterion tests, they appear to benefit the low-CPC students more than the high-CPC students when an additional point can be earned through achieving a grade of A or B. Despite this finding, the criterion tests are probably equally helpful to both groups of students by encouraging them to study and by providing them with feedback for further review. The retests are especially beneficial to the low-CPC students. Overall, a low CPC may affect the final achievement of the student. More than likely, the low-CPC student needs more rehearsal time and a greater reliance on study strategies. With the successful application of the CPC model of teaching and studying, however, the low-CPC students appear to be able to equal the passing and retention rates of the high-CPC students.

CONCLUSIONS

The CPC model of teaching and studying may be a viable one for classroom adoption. The model consists of three components: CPC, pyramid of knowledge, and chunking. The *CPC,* measured by a 6-min test, tells both the teacher and student how many units of information should be considered at one time. A representation of the *pyramid of knowledge,* the CSO, simplifies the counting of units of information to match the learner's CPC. Also, *chunking* of the information can be accomplished by using the headings of the CSO as nexuses. Through such a process, the three experiments presented here show the following results:

1. The success rate of low-CPC students, and probably all other students, may be increased.
2. Withdrawal and noncompletion rates may be reduced.

3. Long-term retention of concepts and principles originally learned may be kept at about the 95% level.
4. Immediate posttest differences between high- and low-CPC students could be eliminated if the latter are given an opportunity for further learning.

To achieve these results, students should be taught the CPC model of studying, provided with a CSO, given frequent quizzes, and given an opportunity to retake tests. The teacher should use the CPC model in teaching.

Despite the successes enumerated, the indications are that the low-CPC students may continue to have a difficult time in achieving As and Bs and be twice as likely to fail. In short, low-CPC students appear to be at a distinct disadvantage, but the use of the CPC model of teaching and studying may minimize and perhaps eliminate this disadvantage.

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REFERENCES

Ausubel, D. P. *Educational psychology—a cognitive view.* New York: Holt, Rinehart & Winston, 1968.

Campbell, D. T., & Stanley, J. C. Experimental and quasiexperimental designs for research. *Handbook of research on teaching.* Chicago: Rand McNally, 1963.

Craik, F. I. M., & Lockhart, R. S. Levels of processing: a framework for memory research. *Journal of Verbal Learning and Verbal Behavior,* 1972, *11,* 671-684.

Furukawa, J. M. *The successful student: study skills.* Minneapolis: Burgess, 1978.

Furukawa, J. M. Cognitive processing capacity effects on prose learning. *Journal of Educational Psychology,* 1977, *69,* 736-743.

Furukawa, J. M. Chunking method of determining size of step in programmed instruction. *Journal of Educational Psychology,* 1970, *61,* 247-254.

Gagné, R. M. *The conditions of learning.* New York: Holt, Rinehart & Winston, 1965.

Horowitz, L. M., & Prytulak, L. S. Redintegrative memory. *Psychological Review,* 1969, *76,* 519-531.

Jones, H. E. Experimental studies of college teaching. *Archives of Psychology,* 1923, *10,* No. 68.

Keller, F. S. Goodbye teacher. . . . *Journal of Applied Behavior Analysis,* 1968, *1,* 79-89.

Mandle. G. Words, lists and categories: An experimental view of organized memory. In J. L. Cowan (Ed.), *Thought and languages.* Tucson, Ariz.: University of Arizona Press, 1969.

McKeachie, W. J. Research on college teaching. *Educational Perspectives,* 1972, *11,* 3-10.

McKeachie, W. J., & Solomon, D. Retention of general psychology. *Journal of Educational Psychology,* 1957, *48,* 110-112.

Miller, G. A. The magical number seven, plus or minus two: some limits on our ability for processing information. *Psychological Review,* 1956, *63,* 81-87.

Morris, C. G. *Psychology: an introduction* (2d ed.). Englewood Cliffs, N.J.: Prentice-Hall, 1976.

Morris, C. J., & Kimbrell, G. M. Performance and attitudinal effects of the Keller method in an introductory psychology course. *Psychological Record,* 1971, *22,* 523-530.

Moss, J. L. Study guide and workbook. *Psychology: an introduction* (2d ed.). Englewood Cliffs, N.J.: Prentice-Hall, 1976.

Ryan, G. A. *PSI, Keller's personalized system of instruction: an appraisal.* Washington, D. C.: American Psychological Association, 1974.

Shankweiler, D., & Liberman, I. Y. Misreading: a search for causes. In J. F. Kavanaugh & I. G. Mattingly (Eds.) *Language by ear and by eye.* Cambridge, Mass.: The MIT Press, 1972.

Sterret, M. D., & Davis, R. A. The permanence of school learning: a review of studies. *Educational Administration and Supervision,* 1954, *40,* 449-460.

Wertheimer, M. Untersuchung zur Lehre von der Gestalt, II. *Psychol. Forsch.*, 1923, *4,* 301-350. Translated and condensed as: Laws of organization in perceptual forms. Ellis, W. D. *A sourcebook of Gestalt psychology.* New York: Harcourt, Brace, & World, 1938.

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